MODULAR PLASMA ARC TORCH

FIELD OF THE INVENTION

[0001] The present invention relates generally to plasma arc torches and more particularly to devices and methods for assembling and disassembling torch components such as a torch head and a torch lead within the plasma arc torch.

BACKGROUND OF THE INVENTION

[0002] Plasma arc torches, also known as electric arc torches, are commonly used for cutting, marking, gouging, and welding metal workpieces by directing a high energy plasma stream consisting of ionized gas particles toward the workpiece. A typical manual plasma arc torch generally includes a torch head comprising nonremovable components (e.g., anode, cathode), and removable components, commonly referred to as consumables, along with a torch handle that houses or covers at least a portion of the torch head and other torch components. The torch handle also houses at least a portion of a torch lead, which generally provides a conduit for the supply of both gas and electric power to the torch head for operation of the plasma arc torch. Further, the torch handle is preferably constructed of an insulating material and is designed to allow a user to conveniently handle and operate the plasma arc torch.

[0003] An upper portion of the torch head typically includes a torch body or housing in which the nonremovable components such a cathode, an insulating body, and an anode are positioned, whereas a lower portion of the torch

head is typically configured to accommodate the removable consumable components. Generally, consumable components have a much shorter life than other components of a plasma arc torch and are thus replaced on a more regular basis. The consumable components may include, by way of example, an electrode, a torch tip (or nozzle), a gas distributor, and a shield cup. Further, the consumable components are typically releasably attached or connected to the torch body and/or to the nonremovable components within the torch body, thereby allowing the consumable components to be easily replaced on a regular basis.

[0004] Additionally, the upper portion of the torch head is typically connected to the torch lead within the handle of the plasma arc torch, wherein such a connection is typically fixed rather than releasable as with the consumable components. Occasionally, the fixed connection between the torch head and the torch lead must be broken if a new torch head or a new torch lead is required. For example, if a torch lead is damaged and requires replacement, the lead is replaced in its entirety by removing a series of connections and fittings, such as electrical wires and compression fittings, and reattaching a new torch lead through the same set of connections and fittings. With plasma arc torches of the known art, however, replacing the torch lead or the torch head is relatively time-consuming and rather cumbersome.

[0005] Alternately, the entire torch lead and the torch head assembly may be replaced rather than replacing the torch lead or torch head separately. Although replacing the entire assembly is more time efficient, the associated cost is much higher than replacing an individual torch head or torch lead. Therefore, a

tradeoff exists between replacing individual components at a lower cost but with more time, and replacing an entire torch assembly at a higher cost but in less time.

[0006] Additionally, known plasma arc torches generally include specific components that are designed for a specific set of performance requirements such as a torch head, a trigger, and a torch lead, among others, which together comprise a torch assembly for the specific set of performance requirements. Such components are further secured within the torch as previously described, which results in a plasma arc torch that is not easily reconfigurable to meet a different set of performance requirements. For example, if a different power supply were being used, either an entirely different plasma arc torch would be required, or a different torch components would have to be replaced within the torch, which is time consuming and cumbersome as previously described.

[0007] Accordingly, a need remains in the art for a device and method that allows for quick and efficient replacement of torch components within a plasma arc torch, yet which is relatively low cost. A further need exists for such a device and method that is also capable of conducting both gas and electric power for operation of the plasma arc torch and which is also relatively compact so as to not interfere with operation of the plasma arc torch. Yet a further need exists for a reconfigurable plasma arc torch and associated methods of assembly and disassembly.

SUMMARY OF THE INVENTION

[0008] In one preferred form, the present invention provides a modular plasma arc torch comprising a torch head, a torch lead, and a quick disconnect operatively engaged between the torch head and the torch lead such that the torch head and torch lead may be quickly assembled and disassembled. Generally, the quick disconnect comprises a pin fitting that is engaged within a socket adapter such that both gas and electric power for operation of the plasma arc torch are conducted through the quick disconnect. The pin fitting further comprises a plurality of resilient fingers with contact flanges at a proximal end thereof, and the socket adapter further comprises an insulative socket housing with a conductive socket fitting disposed therein. Accordingly, the contact flanges engage the socket fitting to provide electrical contact for supply of the electric power, while the socket housing insulates the area surrounding the quick disconnect during use and operation of the plasma arc torch.

[0009] As used herein, a plasma arc apparatus, whether operated manually or automated, shall be construed by those skilled in the art to be an apparatus that generates or uses plasma for cutting, welding, spraying, gouging, or marking operations, among others. Accordingly, the specific reference to plasma arc cutting torches or plasma arc torches herein should not be construed as limiting the scope of the present invention. Furthermore, the specific reference to providing gas to a plasma arc torch should not be construed as limiting the scope of the present invention, such that other fluids, e.g. liquids, may also be provided to the plasma arc torch in accordance with the teachings of the present invention.

[0010] In another form, the present invention provides a modular plasma arc torch comprising a torch head, a gas control device, and a torch lead. Similarly, a quick disconnect is operatively engaged between the torch head and the gas control device and also between the gas control device and the torch lead. Accordingly, torch components within the plasma arc torch, e.g., torch head, gas control device, torch lead, may be quickly assembled and disassembled.

[0011] In other forms of the present invention, a torch head, a torch lead, and a gas control device are provided that comprise a quick disconnect member disposed within an end thereof, wherein the quick disconnect members conduct gas and electric power for operation of a plasma arc torch while allowing the torch head, the torch lead, and the gas control device to be quickly assembled and disassembled from within the plasma arc torch.

[0012] In yet another form, a quick disconnect for operable engagement of components that conduct both gas and electric power, not necessarily specific to a plasma arc torch, is provided that comprises a pin fitting engaged within a socket adapter as previously set forth. Similarly, the pin fitting comprises a plurality of resilient fingers with contact flanges and the socket adapter comprises a conductive socket fitting disposed within an insulative socket housing. Accordingly, the contact flanges engage the socket fitting to provide electrical contact for supply of the electric power.

[0013] Further, a modular plasma arc torch is provided that comprises a plurality of torch components operatively connected through a corresponding plurality of quick disconnects. Moreover, alternate quick disconnects other than the

pin fitting and socket adapter are provided in other forms of the present invention. In yet another form, a modular plasma arc torch handle is provided, wherein two handle halves may be quickly assembled and disassembled, thereby contributing to the overall modularity of the plasma arc torch.

[0014] Additionally, the present invention provides methods of assembling and disassembling a plasma arc torch, wherein the quick disconnect members as previously described are placed in and removed from engagement with corresponding quick disconnect members of torch components disposed within the plasma arc torch. Thus, the plasma arc torch may be quickly assembled and disassembled for purposes such as replacement or repair, or for production assembly and disassembly, among others.

[0015] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0017] Figure 1 is a perspective view of a manually operated plasma arc apparatus constructed in accordance with the principles of the present invention;

[0018] Figure 2 is a side view of a torch head and a torch lead operatively engaged through a quick disconnect within a plasma arc torch and constructed in accordance with the principles of the present invention;

[0019] Figure 3 is a cross-sectional view of a quick disconnect, taken through the plane of Figure 2, operatively engaged between a torch head and a torch lead within a plasma arc torch and constructed in accordance with the principles of the present invention;

[0020] Figure 4 is a cross-sectional view of a quick disconnect in accordance with the principles of the present invention;

[0021] Figure 5A is a cross-sectional view of a pin fitting engaging a socket adapter for engagement of a quick disconnect in accordance with the principles of the present invention;

[0022] Figure 5B is a cross-sectional view of a pin fitting disengaging a socket adapter for disengagement of a quick disconnect in accordance with the principles of the present invention;

[0023] Figure 6 is a perspective view of a pin fitting of a quick disconnect disposed within a torch head and constructed in accordance with the principles of the present invention;

[0024] Figure 7 is an exploded perspective view of a torch head and a torch lead positioned for engagement, illustrating a threaded connection therebetween, and constructed in accordance with the principles of the present invention;

[0025] Figure 8 is a side view of a torch handle comprising positioning ribs to secure torch components therein and constructed in accordance with the principles of the present invention;

[0026] Figure 9 is a cross-sectional view of a torch head, a gas control device, and a torch lead operatively connected through first and second quick disconnects within a plasma arc torch and constructed in accordance with the principles of the present invention;

[0027] Figure 10 is a perspective view of a modular plasma arc torch with a plurality of torch components operatively connected with a corresponding plurality of quick disconnects;

[0028] Figure 11 is a cross-sectional view of another embodiment of a quick disconnect constructed in accordance with the principles of the present invention;

[0029] Figure 12 is a cross-sectional view of yet another embodiment of a quick disconnect employing canted coil springs and constructed in accordance with the principles of the present invention; and

[0030] Figure 13 is a perspective view of a modular plasma arc torch handle constructed in accordance with the principles of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] The following description of the preferred embodiments is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0032] Referring to the drawings, a modular plasma arc torch according to the present invention is generally operable with a manually operated plasma arc apparatus as indicated by reference numeral 10 in Figure 1. Typically, the manually operated plasma arc apparatus 10 comprises a plasma arc torch 12 connected to a power supply 14 through a torch lead 16, which may be available in a variety of lengths according to a specific application. Further, the power supply 14 provides both gas and electric power, which flow through the torch lead 16, for operation of the plasma arc torch 12. Additionally, electric power as used herein should be construed as comprising not only the main power or current for generation of a plasma arc, but also power for other electrical functions such as signal pins or a pilot return that control additional torch functions, among others used within plasma arc torches.

[0033] Referring now to Figure 2, a modular plasma arc torch according to one embodiment of the present invention is illustrated and generally indicated by reference numeral 20. As shown, the modular plasma arc torch 20 comprises a torch head 22, a torch lead 24, and a quick disconnect 26 operatively engaged between the torch head 22 and the torch lead 24. Accordingly, the torch head 22 is removably connected to the torch lead 24 through the quick disconnect 26, which is described in greater detail below, such that the torch head 22 and the torch lead 24 may be quickly assembled and disassembled. As further shown, the torch components, e.g., torch head 22 and torch lead 24, are disposed within a torch handle 28, one half of which is removed for clarity.

[0034] In operation, both gas and electric power are supplied to the torch head 22 through activation of a trigger system 30. Generally, the trigger system 30 causes a power switch 32 disposed within the torch handle 28 to activate the supply of gas and electric power. Alternately, the trigger system 30 may activate the supply of gas with a gas control device (not shown) disposed within the torch handle 28, which is further described below. Operation of the trigger system 30 is described in greater detail in copending application titled "Plasma Arc Torch Trigger System," filed February 26, 2002, and commonly assigned with the present application, the contents of which are incorporated herein by reference.

[0035] The power switch 32 is in electrical communication with the power supply 14 (shown schematically), which generates and supplies gas and electric power. Accordingly, both gas and electric power are delivered from the power supply 14, through the torch lead 24, and to the torch head 22 for generation of a plasma arc and a subsequent plasma stream that is ejected from a torch tip 34. Therefore, the quick disconnect 26 according to the present invention must be capable of conducting both gas and electric power for operation of the modular plasma arc torch 20. Furthermore, as used herein, the terms proximal or proximal direction should be construed as meaning towards or in the direction of the power supply 14, and the terms distal or distal direction should be construed as meaning towards or in the direction of the tip 34 of the plasma arc torch 12.

[0036] With reference to Figure 3, the quick disconnect 26 according to one form of the present invention is shown operatively engaged between the torch head 22 and the torch lead 24. As shown, the quick disconnect 26 comprises a

conductive pin fitting 40 engaged within a socket adapter 42, the operation of which is described in greater detail below. Further, the socket adapter 42 comprises a conductive socket fitting 44, which is engaged by the pin fitting 40, and which is disposed with an insulative socket housing 46. Additionally, individual wires 41, which are preferably used for main cutting current power, are crimped over grooves 43 defined on the socket fitting 44 with a collar 45 to provide electrical continuity between the wires 41 and the socket fitting 44. Moreover, an insulative sheath 47 is crimped over the wires 41 with a ring 49 to encase and protect the wires 41 from the surrounding environment.

[0037] As further shown, the torch head 22 comprises an insulative housing 50, in which an anode 51 (positive side of the power supply), an insulator body 52, and a cathode 53 (negative side of the power supply) are disposed. In operation, the insulator body 52 insulates the anode 51 from the cathode 53, in addition to performing other gas distribution functions which are described in copending application titled "Contact Start Plasma Arc Torch," filed February 26, 2002, and commonly assigned with the present application, the contents of which are incorporated herein by reference.

[0038] Preferably, the pin fitting 40 is molded within the housing 50, although other methods of connecting the pin fitting 40 to the housing 50 such as a threaded connection may also be employed. Additionally, the anode 51, the insulator body 52, and the cathode 53 are similarly molded within the housing 50 in the preferred form of the present invention, although other connection methods such as a threaded connection may also be employed. In one form of the present

invention, the anode 51, the insulator body 52, and the cathode 53 as an assembly are operatively connected to the housing 50 using a quick disconnect in accordance with the principles of the present invention, which is described in greater detail below.

[0039] Further details of the quick disconnect 26 are shown in Figure 4, wherein the pin fitting 40 comprises a plurality of resilient fingers 54 and a plurality of corresponding contact flanges 56 disposed at a proximal end of the resilient fingers 54. As shown, the contact flanges 56 define a dual taper with first tapered surfaces 57 and second tapered surfaces 58, which facilitate engagement and disengagement, respectively, of the quick disconnect 26 as described in further detail below. Preferably, the socket fitting 44 is secured within the socket housing 46 using a snap ring 59 as shown, although other connection methods may be employed, including the connection as shown and described in copending application "Tamperproof Pin Connection," filed November 9, 2001, Serial No. 10/014,384, which is commonly assigned with the present application and the contents of which are incorporated herein by reference. Accordingly, the socket housing 46 would comprise locking fingers that would engage a collar defined on the socket fitting 44 such that the connection between the socket fitting 44 and the socket housing 46 would be tamperproof.

[0040] As further shown, the socket housing 46 defines a tapered internal shoulder 60 that facilitates insertion of the pin fitting 40, and more specifically the resilient fingers 54, into the socket fitting 44. Additionally, the socket fitting 44 further comprises a sleeve 61 disposed therein, defining a tapered surface

62 that facilitates removal of the pin fitting 40. Moreover, the sleeve 61 also limits the contact area between the contact flanges 56 and the socket fitting 44 for proper operation of the quick disconnect 26. Further, the socket housing 46 also defines radial bores 63 that extend from an exterior of the socket housing 46 to a position adjacent the tapered internal shoulder 60. The radial bores 63 are designed to prevent torch malfunction should a rigid object other than the pin fitting 40 with resilient fingers 54 be inadvertently forced into the socket adapter 42, wherein if such an object were forced into the socket housing 46, the radial bores 63 would cause the socket housing 46 to fracture proximate the location of the radial bores 63, thereby causing gas to leak from the socket adapter 42 and reducing the risk of an inappropriate use of the quick disconnect 26 and any possible torch malfunctions that may result.

[0041] Engagement and disengagement of the quick disconnect 26 in accordance with the present invention is illustrated in greater detail in Figures 5A (engagement) and 5B (disengagement). As shown in Figure 5A, as the pin fitting 40 is inserted into the socket housing 46 along the direction of arrow A, first tapered surfaces 57 of the contact flanges 56 abut the tapered internal shoulder 60 defined within the socket housing 46. As the pin fitting 40 is further inserted into the socket housing 46, the tapered internal shoulder 60 causes the resilient fingers 54 to deflect radially inward as shown allowing the pin fitting 40 to be further inserted into the socket housing 42, through the sleeve 61, and into the socket fitting 44. When the contact flanges 56 of the pin fitting 40 pass through the sleeve 61, the resilient fingers 54 deflect back radially outward such that the contact flanges 56 engage a

distal internal bore 64 defined within the socket fitting 44. Accordingly, electrical contact is made between the pin fitting 40 and the socket fitting 44.

[0042] To further maintain proper contact and to enable engagement and disengagement, an outer diameter of the pin fitting 40 in the area of the contact flanges 56 is larger than an internal diameter of the distal internal bore 64 within the socket fitting 44 such that an engagement force is maintained between the pin fitting 40 and the socket fitting 44 when the contact flanges 56 are disposed within the distal internal bore 64. Additionally, the minimum diameter of the tapered internal shoulder 60, proximate the sleeve 61, is smaller than the outer diameter of the pin fitting 40 in the area of the contact flanges 56 in an undeflected state so that the resilient fingers 54 may be deflected a sufficient amount for insertion into the socket fitting 44.

[0043] Referring now to Figure 5B, the quick disconnect 26 is illustrated during disengagement. As shown, when the pin fitting 40 is removed from the socket adapter 42 along the direction of arrow B, the second tapered surfaces 58 of the resilient fingers 54 engage the tapered surface 62 of the sleeve 61, which causes the resilient fingers 54 to deflect radially inward and the pin fitting 40 may be further removed along the direction of arrow B. After the contact flanges 56 clear the tapered internal shoulder 60, the resilient fingers 54 deflect back radially outward and the pin fitting 40 is disengaged from the socket adapter 42. As a result, the quick disconnect 26 provides a relatively compact and efficient connection between torch components such as the torch head 22 and the torch lead 24, and is further

capable of conducting both gas and electric power for operation of the plasma arc torch 12.

[0044] For conducting gas flow, the pin fitting 40 defines an internal bore 65 that is in fluid communication with the distal internal bore 64 of the socket fitting 44, and also with a proximal internal bore 66 defined by the socket fitting 44, each of which are sized according to specific gas flow requirements. In operation, the gas flows from the power supply 14 (not shown) through the proximal internal bore 66 of the socket fitting 44, through the distal internal bore 64 of the socket fitting 44, and then through the pin fitting internal bore 65 for subsequent delivery to the torch head 22 (not shown). Accordingly, interfaces between the pin fitting 40 and the socket housing 46, and also between the socket fitting 44 and the socket housing 46, are preferably sealed to inhibit the gas from leaking from the quick disconnect 26. In one form of the present invention, first and second o-rings, 68 and 70 respectively, are disposed at the interfaces such that the first o-ring 68 provides a gas-tight seal between the pin fitting 40 and the socket housing 46, and the second o-ring 70 provides a gas-tight seal between the socket fitting 44 and the socket housing 46. Further, the socket housing 46 comprises an o-ring groove 72 to house the first o-ring 68, and similarly, the socket fitting 44 comprises an o-ring groove 74 to house the o-ring 70, although the o-ring grooves may be disposed in either of the members between which a sealed interface is desired.

[0045] For conducting electric power, the pin fitting 40 is in physical contact with the socket fitting 44 as shown, thus the pin fitting 40 and the socket fitting 44 are conductive elements. More specifically, the contact flanges 56 are in

physical contact with the distal internal bore 64 of the socket fitting 44 to provide the requisite electrical contact for supply of the electric power from the power supply 14 (not shown) to the torch head 22 (not shown). As further shown, the contact flanges 56 preferably form a rounded profile between the first tapered surfaces 57 and the second tapered surfaces 58 in order to maintain electrical contact should either or both the pin fitting 40 and the socket adapter 42 become misaligned. Additionally, the socket housing 46 is an insulative element such that the area surrounding the quick disconnect 26 is insulated during use and operation. Preferably, the pin fitting 40 and the socket fitting 44 are a heat treated beryllium copper, and the socket housing 46 is a plastic composition such as Nylon or Delrin®.

[0046] As further shown, the quick disconnect 26 also comprises a plug 80 disposed on a shoulder 81 formed within the socket fitting 44, between the distal internal bore 62 and the proximal internal bore 66. The plug 80 is comprised of a nonconductive material such that if an object other than the pin fitting 40 with resilient fingers 54 were inadvertently inserted into the socket adapter 42, the plug 80 would inhibit electrical contact between the object and the socket fitting 44. Accordingly, the plug 80 reduces the risk of torch malfunction should an object other than the pin fitting 40 with the resilient fingers 54 be inserted into the socket adapter 42.

[0047] Referring to Figure 6, the pin fitting 40 is preferably cylindrical in shape, although other shapes may be employed in accordance with the teachings of the present invention. Preferably, a total of four (4) resilient fingers 54 are employed in the embodiment as illustrated herein, although a different number of resilient

fingers 54 may be used according to specific application requirements without departing from the scope of the present invention. Additionally, the pin fitting 40 is illustrated as being disposed within a proximal end 82 of the torch head 22, however, the pin fitting 40 may alternately be disposed within the torch lead 24 (not shown) while the socket adapter 42 (not shown) is disposed within the torch head 22. Therefore, either side of the quick disconnect 26, i.e. plug fitting 40 and socket adapter 42, may be disposed within distal and proximal ends, respectively, of adjoining torch components and remain within the scope of the present invention. In addition to the proximal end 82, the torch head 22 may also comprise a quick disconnect member, i.e. the pin fitting 40 or the socket adapter 42, at a distal end 83 for quickly connecting and disconnecting an anode, insulator body, and cathode assembly (not shown), which is described in greater detail below.

[0048] Referring now to Figure 7, the connection between the torch head 22 and the torch lead 24 may be further secured through a secondary connection, namely, a threaded connection between the torch head 22 and the torch lead 24. The threaded connection is achieved through a threaded extension 84 defined by the socket housing 46 that engages a threaded member 86 disposed within the proximal end 82 of the torch head 22. As shown, the threaded extension 84 defines external threads 85 and extends from the socket housing 46, while the threaded member 86 defines internal threads 87 and is disposed at the proximal end 82 of the torch head 22 proximate the pin fitting 40. After the pin fitting 40 is engaged within the socket adapter 42, the quick disconnect 26 is further secured by threadably engaging the external threads 85 of the threaded extension 84 with the

internal threads 87 of the threaded member 86. The threaded connection also provides an additional amount of coaxial translation of the pin fitting 40 relative to the socket adapter 42 so as to further engage and secure the quick disconnect 26. Preferably, the socket housing 46 is rotatably mounted to the socket fitting 44 such that the threaded connection may be engaged without rotating the entire torch lead 24, which could result in an undesirable twisting of the torch lead 24. Accordingly, the snap ring 59 (not shown) as previously described provides the rotatable mounting such that the socket housing 46 may be rotated independently without turning the entire torch lead 24 and the socket adapter 42.

[0049] In another form, the threaded connection may further comprise thread protrusions and thread engagement members and as shown and described in copending application titled "Dual Pitch Locking Connector," filed November 9, 2001, and commonly assigned with the present application, the contents of which are incorporated herein by reference in their entirety. Generally, the threaded member 86 comprises two diametrically opposed radial protrusions (not shown) that engage the external threads 85 of the threaded extension 84. Further, the external threads 85 comprise at least one thread protrusion (not shown) such that at least one radial protrusion engages the thread protrusion to provide an audible and tactile indication of a fully mated condition of the quick disconnect 26.

[0050] As shown in Figure 8, the connection between the torch head 22 (not shown for clarity) and the torch lead 24 (not shown for clarity) may alternately be further secured through the use of positioning ribs 89 within the torch handle 28, rather than the threaded connection as previously described. After the

pin fitting 40 is engaged within the socket adapter 42 as previously described, the torch head 22 and the torch lead 24 are placed within a half of the torch handle 28 between positioning ribs 89a and 89b, which prevent movement of either the torch head 22 or the torch lead 24 in a direction away from the quick disconnect 26. Accordingly, the positioning ribs 89a and 89b further secure the connection between the pin fitting 40 and the socket adapter 42. Furthermore, the positioning ribs 89a and 89b may be disposed in either or both halves of the torch handle 28 and are preferably integrally formed within the torch handle 28, although the positioning ribs 89a and 89b may alternately be separately attached within the torch handle 28 without departing from the scope of the present invention.

[0051] The quick disconnect 26 according to the present invention may also be employed to provide a connection between additional torch components within a plasma arc torch 12 rather than or in addition to between a torch head 22 and a torch lead 24 as previously described. For example, other torch components that may be quickly assembled and disassembled using the quick disconnect 26 according to the present invention may comprise gas flow control components such as valves and orifices, electrical components such as voltage circuits, logic boards, and/or switches, torch head components such as an anode, a cathode, and an insulator, electrical adapters, and torch handles, among others. Accordingly, each component of a plasma arc torch may be easily and rapidly connected and disconnected according to the principles of the present invention, thereby providing a modular plasma arc torch that has not heretofore been observed in plasma arc torches.

[0052] As shown in Figure 9, the quick disconnect 26 is further employed between the torch head 22 and a gas control device 90, (shown as a first quick disconnect 26a), and also between the gas control device 90 and the torch lead 24, (shown as a second quick disconnect 26b) in another form of the present invention. Generally, the gas control device 90 is employed to provide control of the gas supply local to the torch handle 28 of the plasma arc torch 12 and is activated by the trigger system 30. Additionally, gas control local to the torch handle 28 is disclosed in copending application titled "Torch Handle Gas Control" filed on February 26, 2002, and commonly assigned with the present application, the contents of which are incorporated by reference.

[0053] As shown, the gas control device 90 comprises a distal end 92 and a proximal end 94, in which quick disconnect members as previously shown and described are disposed. For example, a socket adapter 42a as previously described may be disposed within the distal end 92 of the gas control device 90 as shown, such that a pin fitting 40a disposed within the proximal end 82 of the torch head 22 is engaged within the socket adapter 42a. Alternately, the socket adapter 42a may be disposed at the proximal end 82 of the torch head 22, while the pin fitting 40a is disposed within the distal end 92 of the gas control device 90. As further shown, a pin fitting 40b is disposed within the proximal end 94 of the gas control device 90, which is engaged within a socket adapter 42b disposed within the distal end 93 of the torch lead 24. Alternately, the socket adapter 42b may be disposed within the proximal end 94 of the gas control device 90, while the pin fitting 40b is disposed within the distal end 93 of the torch lead 24.

[0054] Accordingly, the torch head 22 is removably connected to the gas control device 90 through the first quick disconnect 26a, and the gas control device 90 is removably connected to the torch lead 24 through the second quick disconnect 26b such that the torch head 22, the gas control device 90, and the torch lead 24 may be quickly assembled and disassembled, thereby forming a modular plasma arc torch. Further, both the gas and electric power are conducted through the first quick disconnect 26a and the second quick disconnect 26b for operation of the plasma arc torch 12. Although the present invention is directed to use of the quick disconnect 26 for a connection between the torch head 22, the gas control device 90, and/or the torch lead 24, the quick disconnect 26 may also be employed with other torch components disposed within the plasma arc torch 12 in accordance with the teachings of the present invention.

[0055] For example, Figure 10 illustrates a plasma arc torch 12 with a plurality of torch components having a quick disconnect 99 operatively engaged between each of the torch components. As shown, the quick disconnect 99 may be employed between a torch head 100 and an adapter 102 within a torch handle 104. As a result, the torch handle 104 does not necessarily require disassembly for replacement of the torch head 100. Further, the quick disconnect 99 may be employed between a cathode, insulator, anode assembly 106 and the torch head 100, between a torch lead 108 and the adapter 102, between a gas flow control component 110 and the torch lead 108, between an electrical component 112 and the torch lead 108, between a proximal end 114 of the torch lead 108 and an adapter 116 for connection to a particular power supply, and between a plurality of

signal and power pins 118 and a conductive member 119, among a multitude of other possible combinations of torch components which are too numerous to detail herein. Therefore, it should be understood by those skilled in the art that any number of torch components may incorporate a quick disconnect to provide a modular plasma arc torch that is within the scope of the present invention and the use of specific examples herein should not be construed as limiting the scope of the present invention.

[0056] In addition to the quick disconnect 26 as shown and described with the pin fitting 40 and a socket adapter 42, other quick disconnects may also be employed between various torch components as described herein in order to achieve a modular plasma arc torch without departing from the scope of the present invention. For proper operation of the plasma arc torch, however, the quick disconnect that is employed must be capable of conducting both electric power and gas through the quick disconnect and between torch components. For example, the quick disconnect may comprise a dual pitch locking connector as shown and described in copending application titled "Dual Pitch Locking Connector," filed November 9, 2001, Serial No. 10/035534, which is commonly assigned with the present application and the contents of which are incorporated herein by reference. Alternately, the quick disconnect may comprise a pin and socket configuration wherein resilient fingers are disposed on a socket side of the quick disconnect rather than a pin side, such as on the main power socket as shown and described in copending application titled "Plasma Arc Torch Quick Disconnect," filed November 9,

2001, which is commonly assigned with the present application and the contents of which are incorporated herein by reference.

[0057] Referring to Figure 11, the quick disconnect may alternately comprise pin and socket members, 120 and 122 respectively, that are engaged and secured by a locking ring 124. As shown, a conductive pin 126 defining a central bore 128 is engaged within a conductive socket 130, which similarly defines a central bore 132. In operation, a working gas is conducted through the central bores 128 and 132, and electric power is conducted through the conductive pin 126 and the conductive socket 130. Accordingly, an o-ring 133 or other sealing member commonly known in the art is preferably disposed within the quick disconnect as shown to seal the supply of gas. Further, the locking ring 124 secures a pin housing 134 to a socket housing 136 through a threaded connection 138, or through other connection methods commonly known in the art such as a snap-lock or a pin and groove, among others. Accordingly, torch components may be quickly assembled and disassembled through the use of pin and socket members, 120 and 122, in addition to the locking ring 124.

[0058] As shown in Figure 12, the quick disconnect may alternately comprise at least one canted coil spring 140 disposed within a socket 142 that engages and secures a pin 144 that is slidably disposed within the socket 142. In operation, the pin 144 is inserted into the socket 142 and compresses the canted coil spring 140 upon engagement such that the canted coil spring 140 applies a radially inward force to secure the pin 144 within the socket 142. Preferably, the canted coil spring 140 is also conductive so as to minimize any loss of electrical

continuity across the interface between the pin 144 and the canted coil spring 140. Additionally, a threaded connection may also be employed as previously described to further secure the connection between the pin 144 and the socket 142.

[0059] Referring now to Figure 13, yet another form of the modular plasma arc torch is facilitated through the use of a modular torch handle 150. Rather than individual fasteners to secure first and second torch halves 150a and 150b, respectively, the torch halves 150a and 150b define flexible tabs 152 and receptacles 154, respectively, in one form of the present invention. As shown, the flexible tabs 152 are disposed along an upper periphery 156 of torch half 150a and are preferably integrally molded with the torch half 150a. The corresponding set of receptacles 154 are disposed along an upper periphery 158 of the torch half 150b and are also preferably integrally molded with the torch half 150b. Additionally, the torch half 150a defines positioning pins 160 along a lower periphery 162, and the torch half 150b defines corresponding positioning holes 164 along a lower periphery 166. Similarly, the positioning pins 160 and the positioning holes 164 are preferably integrally molded with the torch halves 150a and 150b, respectively.

[0060] To quickly assemble the torch halves 150a and 150b, therefore, the positioning pins 160 are placed within the positioning holes 164 along the lower peripheries 162 and 166, and the upper peripheries 156 and 158 are brought together such that the flexible tabs 152 may be engaged with the receptacles 154. Accordingly, the flexible tabs 152 are depressed while the upper peripheries 156 and 158 are further brought together to engage the receptacles 154 as shown. It should be understood by those skilled in the art that one or a plurality of flexible tabs 152

and corresponding receptacles 154 may be employed without departing from the scope of the present invention. Additionally, the relative position of the flexible tabs 152 and the receptacles 154, in addition to the positioning pins 160 and the positioning holes 164, along the peripheries may be altered while remaining within the scope of the present invention.

[0061] In yet another form of the present invention, a method of assembling the a plasma arc torch with the torch head 22 and torch lead 24 is provided. The method comprises the step of placing a quick disconnect member, (i.e., plug fitting 40 or socket adapter 42), that is disposed within a distal end of the torch lead 24 in engagement with a corresponding quick disconnect member, (i.e., socket adapter 42 or plug fitting 40, respectively), that is disposed within the proximal end 82 of the torch head 22. Accordingly, the torch head 22 and the torch lead 24 are quickly assembled. Further, the method may comprise the step of engaging a threaded member disposed on one of the quick disconnect members with a threaded extension on the corresponding quick disconnect member, such that the torch head 22 is further secured to the torch lead 24.

[0062] In another form, the present invention provides a method of assembling a plasma arc torch with the torch head 22, the quick disconnect 90, and the torch lead 24 components. The method comprises the steps of placing a quick disconnect member disposed within a distal end of the torch lead 24 in engagement with a corresponding quick disconnect member disposed within the proximal end 94 of the gas control device 90, and placing a quick disconnect member disposed within the distal end 92 of the gas control device 90 in engagement with a corresponding

quick disconnect member disposed within the proximal end 82 of the torch head 22, such that the torch head 22, the torch lead 24, and the gas control device 90 are quickly assembled. Additionally, the method may comprise the step of engaging threaded members disposed on one set of quick disconnect members with threaded extensions on the corresponding quick disconnect members, such that the torch head 22 is further secured to the gas control device 90, and the gas control device 90 is further secured to the torch lead 24.

[0063] In yet another form of the present invention, a method of disassembling a plasma arc torch with the torch head 22 and the torch lead 24 disposed therein is provided. The method comprises the step of disengaging a quick disconnect member disposed within a distal end of the torch lead 24 from engagement with a corresponding quick disconnect member disposed within the proximal end 82 of the torch head 22, such that the torch head 22 and the torch lead 24 are quickly disassembled. Similarly, the method may further comprise the step of disengaging a threaded member disposed on one of the quick disconnect members with a threaded extension on the corresponding quick disconnect member prior to disengaging the quick disconnect member disposed within the distal end 93 of the torch lead 24 from engagement with the corresponding quick disconnect member disposed within the proximal end 82 of the torch head 22, such that the torch head 22 is unsecured from the torch lead 24.

[0064] Furthermore, a method of disassembling a plasma arc torch with the torch head 22, the gas control device 90, and the torch lead 24 disposed therein is provided. The method comprises the steps of disengaging a quick

disconnect member disposed within a distal end of the torch lead 24 from engagement with a corresponding quick disconnect member disposed within the proximal end 94 of the gas control device 90 and disengaging a quick disconnect member disposed within the distal end 92 of the gas control device 90 from engagement with a corresponding quick disconnect member disposed within the proximal end 82 of the torch head 22, such that the torch head 22, the torch lead 24, and the gas control device 90 are quickly disassembled. Additionally, the method may comprise the step of disengaging threaded members disposed on the quick disconnect members from threaded extensions on the corresponding quick disconnect members, such that the torch head 22 is unsecured from the gas control device 90 and the gas control device 90 is unsecured from the torch lead 24 prior to disengaging the quick disconnect members.

[0065] Accordingly, the modular plasma arc torch 20 according to the teachings of the present invention provides devices and methods that allow for quick and efficient assembly and disassembly of a wide variety of torch components within a plasma arc torch. Torch components may be easily removed and replaced if damaged, and furthermore, a reconfigurable torch is provided wherein different design functions may be provided by adding or removing torch components, e.g., inserting or removing the gas control valve. Further, the various quick disconnects employed within the modular plasma arc torch 20 are capable of conducting both gas and electric power, and are relatively compact so as to not interfere with operation of the plasma arc torch 12.

[0066] The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the substance of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.